The Growth and Development of the Eastern Barred Bandicoot *Perameles gunnii* in Victoria

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Abstract

A growth curve of head length provided a means of assessing the age of *Perameles gunnii* from birth to four months. Measurements of body weight were used to detemine the age of bandicoots to 10 months. The development of neonates to emergent pouch young is described. Juvenile *P. gunnii* may emerge for short periods after 46 days of pouch life and re-enter the pouch until day 53. Weaning of offspring occurs when young are between 50 and 57 days old. Juvenile *P. gunnii* that have emerged from the pouch may remain dependent on their mother for some time. Offspring that were aged between 57 and 86 days were observed associating closely with their mother during her nocturnal foraging. *Perameles gunnii* aged between three and six months and independent of their mothers were referred to as subadult. Hence, three developmental stages were recognised for *P. gunnii*: juvenile (0 - 3 months), sub-adult (3 - 6 months), and adult (greater than six months).

Introduction

The comprehensive description of a population's demography depends largely on the ability to accurately determine the age of individuals. For endangered species, age determination and subsequent life-table analysis can be used to calculate population viability and age-specific rates of reproduction and survival and highlight actions that will most effectively lead to population or species recovery. The remnant mainland population of the Eastern Barred Bandicoot, *Perameles gunnii* is highly endangered and persists only at Hamilton, Victoria (Brown 1989).

During recent live-trapping studies in Victoria, the age structure of the population of *P. gunnii* at Hamilton was arbitrarily estimated using body weight; individuals that weighed more than 500 g were described as adult (Brown 1989; Minta *et al.* 1990; Dufty 1991 *a*). In Tasmania, Heinsohn (1966) defined male and female *P. gunnii* that were six and four months respectively as adult and based his estimates on a combination of head length and body weight. Despite these definitions, no standard method of ageing *P. gunnii* exists.

This paper examines weight and morphometric data collected during recent monitoring of a captive breeding colony of *P. gunnii* at Gellibrand Hill Park in order to develop a means of assessing the age of *P. gunnii*. This information was then applied to data from the free-ranging population at Hamilton and the captive breeding colony at Gellibrand Hill Park to describe the growth and development of *P. gunnii*.

Methods

Weekly and bi-weekly monitoring of a captive breeding colony at Gellibrand Hill Park between August 1988 and December 1989 allowed regular measurements and observations of pouch young to be made. The growth and development data for free-ranging *P. gunnii* was recorded during monthly live-trapping at the Hamilton Municipal Tip between 1989 and 1990 (Dufty 1994 *b*). Measurements of growth (to the nearest 0.1 mm using dial calipers) and observations of development of pouch young were undertaken *in situ*. No litters that were examined at Hamilton were assumed to include neonates (between 1 - 5 days old). The age of young *P. gunnii* observed at Hamilton was estimated from growth curves of head length and body weight that were constructed from data collected at Gellibrand Hill Park.

Avoidance behaviour is commonly observed between *P. gunnii* of different ages and sexes (Dufty 1994 *a*). Hence, adult females that were observed to be associating closely with young (e.g. an adult female and young that were live-trapped together) but displayed little or no antagonism toward them, were assumed to be the mother of the

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young. Young that had emerged from the pouch but were associating closely with an adult female were referred to as post-emergent dependent juveniles. Standard measurements of head, ear, foot, tail and scrotum (Brown 1989; Dufty 1991 *a*; 1991*b*) were recorded for juvenile, subadult and adult *P. gunnii*.

Results

Growth curves for head length and body weight were plotted from 58 encounters of 12 litters (totalling 33 individuals) that were first recorded as neonates at Gellibrand Hill Park (Fig. 1 and 2). These growth curves, and the morphometric data collected in the field, allowed the age of a further 145 young in 66 litters observed at Hamilton to be estimated. Also, ten juveniles (in eight litters) were caught in the same trap as their mothers and their body weight, morphology and behaviour were recorded. Hence, the growth of 188 young in 86 litters from both captive and free-ranging populations was reported (Table 1 and 2), and of these, the development of 27 pouch young in 13 litters was described (Table 3).

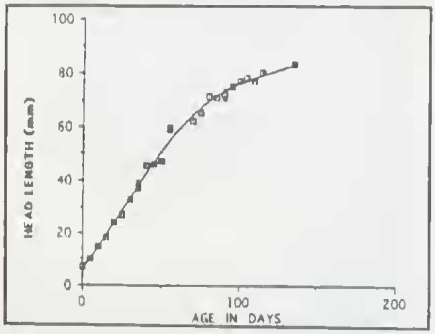


Fig. 1. The growth in head length of 33 *Perameles gunnii* that were first encountered as neonates in the captive breeding colony at Gellibrand Hill Park, Victoria. Values are means ± standard error and line of best fit was plotted from a polynomial equation to the order of 3 ($y = 4.84 + 1.06x - 0.003x^2 - 5.88e - 6x^2$ R = 1.0).

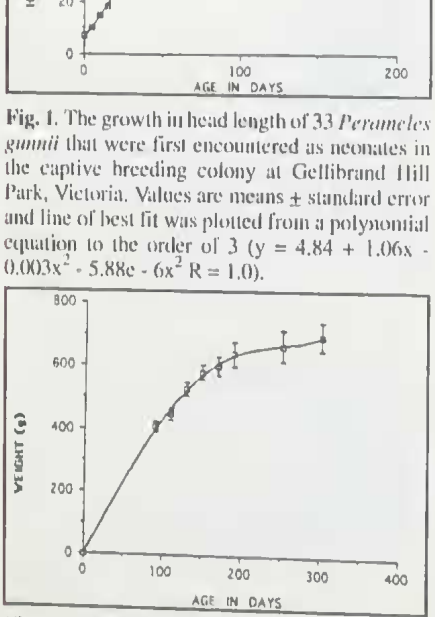


Fig. 2. The growth in body weight of 33 *Perameles gunnii* in the captive breeding colony at Gellibrand Hill Park, Victoria. Values are means ± standard error and line of best fit was plotted from a polynomial equation to the order of 4 ($y = 0.32 + 4.51x - 0.006x^2 - 1.02e - 4x^3 + 0.0e + 0x^4$ R = 1.0).

Description of neonate

Two litters of neonates totalling seven *P. gunnii* were known to be born within 24 h of examination and were described *in situ*. The mean head length was 5.75 mm (n=7) and mean crown-rump length was 13.6 mm (n=7). Neonates were reddish-pink in colour with hairless, glossy skin that was slightly moist to touch. The mouth comprised a circular opening firmly enclosed upon a teat by an enlarged tongue that slightly protruded from the mouth. The nostrils were tubular and prominent on an abruptly ending snout. The eyes were represented by dark grey pigmentation that formed a ring under a translucent membrane. Neither ears nor sex was distinguishable. The forelimbs were well developed, with three toes on each limb, compared to the hind limbs that resembled flippers with two rudimentary digits on each. The tail was well developed and about 3 - 4 mm long, curving ventrally between the hind limbs. The neonates often moved during the examinations. In general, the forelimbs moved randomly while the hindquarter moved more saltatorially with the curved spine straightening as the hind limbs pushed backwards.

Description of emergent pouch young

The oldest pouch young observed were estimated to be 53 days old. The mean head length and body weight of emergent pouch young (between day 46 and 53) were 47.2 mm (n=10; range 49 - 44 mm) and 81.4 g (n=4; range 140 - 42.5 g) respectively. Their ears were erect, facing forward and 28.1 ± 0.2 mm (n=2) high and their tail was 49.2 ± 0.7 mm (n=2) long. The young's eyes were open, all whiskers were present and fur covered the body to a length of 5 mm. The

Table 1. Growth of head length, foot length and body weight for 145 pouch young in a free-ranging population of *Perameles gunnii* at Hamilton, Victoria. Values are means ± standard errors with the

Age (days)	Head length (mm)	Foot length (mm)	Body weight (g)	Age (days)	Head length (mm)	Foot length (mm)	Body weight (g)
1	5.8 ± 0.1 (2)			27	25.8 ± 0.2 (3)	16.6 2.4 (2)	
2	6.5 ± 0.0 (3)			28	26.8 ± 0.8 (2)	19.3 ± 1.6 (2)	
3	7.2 ± 0.3 (2)			29	27.0 ± 0.5 (2)	16 (1)	
4	8.0 (1)			30	29.0 (1)		
5	8.4 ± 0.1 (4)			31	29.6 ± 0.2 (5)	19.1 ± 1.2 (5)	
6	8.8 (1)			32	32.3 ± 1.3 (2)	25.0 ± 0.5 (2)	
8	9.3 ± 0.3 (3)			34	32.6 ± 0.1 (2)	24.9 (1)	
10	10.5 ± 0.2 (6)			35	34.5 (1)	30.5 (1)	
11	12 ± 0 (3)			36	34.7 0.2 (3)	28.0 4.0 (3)	
12	12.5 ± 1.5 (2)			38	36.9 ± 0.5 (2)	31.3 ± 4.6 (2)	
14	14 (1)			42	40.7 ± 0.3 (3)	34.2 ± 1.0 (3)	30.0 (1)
15	14.8 ± 0.7 (3)	6.4 ± 1.4 (2)		44	44.3 0.8 (2)	41.8 0.3 (2)	70.0 (1)
16	16 (1)	6 (1)		45	43.8 (1)	38 (1)	
17	16 (1)	7 (1)		46	44 (1)	42 (1)	
18	17.4 ± 0.4 (7)	8.4 ± 0.6 (7)		47	44.8 (1), 41.5 (1)	66.0 (1)	
19	19.3 ± 0.8 (2)	9.5 ± 1.5 (2)		48	47.0 ± 0 (2)	46.8 ± 1.3 (2)	77.0 (1)
21	21.4 ± 0.3 (5)	11.7 ± 0.7 (3)		49	48 ± 0.5 (2)	46 ± 0.5	
22	22.7 ± 0.5 (3)	12.3 ± 0.5 (3)		50	48 ± 0.5 (2)	41.8 ± 3.75 (2)	42.5 (1)
24	22.5 ± 0.5 (2)	14.5 (1)		51	48.2 (1), 48.1 (1)	140 (1)	
25	23.8 ± 0.8 (2)	12.4 (1)		53	49 (1), 45 (1)		
26	25.5 (1)	18.8 (1)					

fur was very fine and soft to touch and pigmented a golden brown with distinct cream and dark patches that delineated bars on their hindquarters. The young were often found detached from a teat (one young was observed suckling two teats simultaneously) and were sometimes heard making soft squeaking noises. During examinations, the young were very curious and often sniffed and nuzzled objects e.g. fingers placed within the pouch. During this time, young may voluntarily emerge for short periods and later re-enter the pouch. On one occasion, after both mother and young were crouched on the trap floor, the young was observed re-entering the pouch. As the trap was approached, the mother raised herself to a standing position, arched her back and lifted her left forelimb to expose the pouch. The young promptly re-entered the pouch while the mother maintained her vigil. The age of the young was estimated to be about 53 days.

Description of post-emergent dependent young

Although not observed during the study, emergent young were probably left in a nest during the mother's nocturnal foraging. Many adult females were observed lactating, having greatly extended nipples, about 40 mm long, but without pouch young. This period of lactation when pouch young were absent, occurred between pouch emergence (day 53) and day 57. Eight post-emergent juvenile *P. gunnii* were captured with their mothers. The youngest of these juveniles was estimated to be 57 days while the oldest was 86 days. All mothers that were caught with post-emergent juveniles were not lactating or lactated with very immature young. Therefore, *P. gunnii* appeared to be weaned off milk by about day 57 but still depended on their mothers to find solid food. The

Table 2. Mean size of live-trapped juveniles (aged 0 - 3 months), subadults (aged 3 - 6 months) and adults (aged 6 months or older), excluding pouch young, in a free-ranging population of *Perameles gunnii* at Hamilton, Victoria. Mean values are ± standard error.

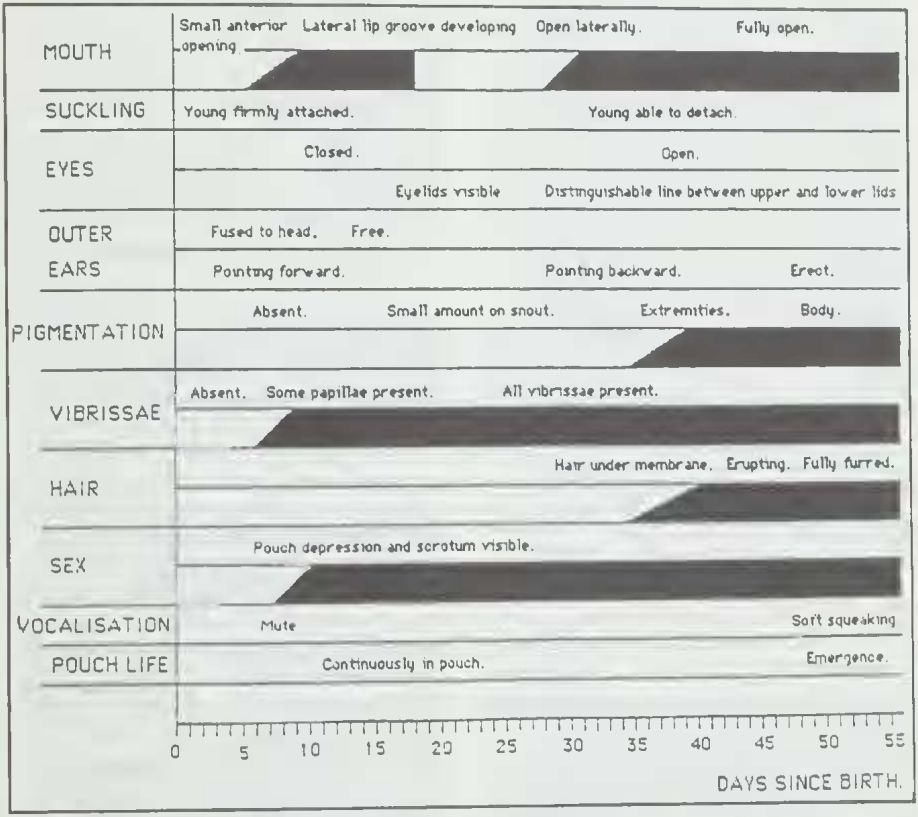
Characteristic	Mean size	Number	Minimum	Maximum
a) Juvenile				
Body weight	286.4 ± 29 g	18	135 g	480 g
Head length	65.1 ± 1.4 mm	18	53.0 mm	73.8 mm
Foot length	62.6 ± 1.2 mm	15	54.0 mm	68.7 mm
Ear length	37.9 ± 1.6 mm	18	31.8 mm	44.8 mm
Tail length	71.3 ± 2.6 mm	11	53.5 mm	83.5 mm
Scrotal length	11.7 ± 1.1 mm	9	7.8 mm	18.2 mm
Scrotal width	13.8 ± 1.4 mm	9	9.0 mm	21.8 mm
b) Sub-adult				
Body weight	546.9 ± 9.9 g	34	405 g	640 g
Head length	79.8 ± 0.6 mm	30	74.5 mm	89.0 mm
Foot length	70.1 ± 0.5 mm	30	66.0 mm	75.0 mm
Ear length	42.3 ± 0.7 mm	30	35.0 mm	47.0 mm
Tail length	83.6 ± 1.3 mm	27	73.8 mm	97.9 mm
Scrotal length	19.6 ± 1.4 mm	11	12.0 mm	26.5 mm
Scrotal width	23.4 ± 1.6 mm	11	13.3 mm	29.5 mm
c) Adult				
Body weight	805.8 ± 4.8 g	236	645 g	950 g
Head length	86.9 ± 0.2 mm	225	78.4 mm	95.2 mm
Foot length	75.1 ± 0.2 mm	223	68.0 mm	81.5 mm
Ear length	45.9 ± 0.2 mm	222	38.5 mm	52.0 mm
Tail length	91.6 ± 0.4 mm	184	75.0 mm	105 mm
Scrotal length	27.9 ± 0.2 mm	136	21.7 mm	33.0 mm
Scrotal width	33.1 ± 0.2 mm	136	26.3 mm	39.2 mm

average head length and body weight of the live-trapped post-emergent dependent juveniles were 59.9 mm (n=8; range 70 - 53 mm) and 161.4 g (n=7; range 220 - 135 g) respectively.

On one occasion when mother and young had been caught in the same trap, the young attempted to enter the pouch but was refused. The mother adopted an arched-back stance (described earlier) but held her pouch closed. When the pouch of the mother was examined, three 2 day old pouch young were found. The post-emergent young was estimated to be about 70 days old and if the gestation period of *Perameles gunnii* is assumed to be about 12.5 days (Lyne 1974), these pouch young were probably conceived when the emergent young were about 56 days old (just weaned).

The live-trapping of both mother and young in the same trap indicates that juveniles continue to be closely associated with, and dependent on, their mother for some time after weaning. During one occasion, two juvenile females (about 57 days old) were trapped with their mother. Upon unassisted emergence from the handling bag, the mother moved quickly into some tussock grass about 1.5 m to the north. One young followed her closely, while the other headed west but stopped about 2 m from her mother and made a soft squeak that was repeated five times at about one second intervals. The mother backtracked about half a metre and made a single low 'honk' that attracted the young to her and reunited the trio. The mother then slowly moved east out of cover at a walking pace and jumped onto the wire mesh of a mattress base. Again one young followed closely and climbed onto the base while the other (the one that was initially lost) went under the wire mesh of the base. Although this young could hear and see her mother, she remained out of contact. Exten-

Table 3. The development of pouch young of eastern barred bandicoot, *Perameles gunnii* in Victoria. Descriptions were based on observations of 27 young in 13 litters in both the free-ranging population at Hamilton and captive population at Gellibrand Hill Park, Victoria.



sive vocalisations and searching for a break in the mesh by both mother and young were perceived until, probably by chance, the mother and young jumped off the base and the trio was reunited a second time. The mother then led the young northwards into a pile of Monterey Cypress *Cupressus macrocarpa* limbs where they were last seen.

Description of sub-adult

Sub-adults appear to be proportionally similar to, though smaller than, adult *P. gunnii* (Table 2). The youngest female to successfully mate was about three months old although the mean age of females at first successful mating was 3.5 months (109 days; n=9). The onset of male sexual maturity is more difficult to determine using morphometric data. The growth of the scrotum appears to plateau when *P. gunnii* are about 5 - 6 months (about 640 g body weight). Therefore, independent *P. gunnii* reach sexual maturity between 3 and 6 months. The period when *P. gunnii* are subadult can be morphometrically defined as when head length is greater than 74 mm and body weight is greater than 400 g but equal to or less than 640 g.

Discussion

During this study, *P. gunnii* were grouped into three age classes: 0 - 3 months (juvenile), 3 - 6 months (subadult) and greater than 6 months (adult). These age classes also represent developmental stages. The juvenile stage is when young are dependent on their mother for nutrition and shelter; the sub-adult stage represents when young are independent, becoming sexually mature and developing to full adult size, and; the adult

stage is when *P. gunnii* are fully mature and independently established in their own home range. Dufty (1994 *b*) utilised these three age classes and further subdivided the adult group into three-month intervals to facilitate more intensive demographic analysis. Lyne (1964), Brown (1989) and Minta *et al.* (1990) classified the population on the basis of body weight into juvenile and adult. Dufty (1991*a*) utilised three age classes: less than 150 g, between 150 and 500 g, and greater than 500 g to designate juvenile, sub-adult and adult groups respectively. During this study, head length was favoured over body weight and foot length due to the greater consistency of measurement, the slow growth of body weight and foot length early in development, and the ease of head length measurement for *P. gunnii* of all ages. Lyne (1964) and Heinsohn (1966) also believed head length to be the most suitable measurement for ageing juvenile bandicoots. Head length measurements were accurate for age estimation of juveniles and subadults. However, the growth of *P. gunnii* slowed after six months while variations due to individual and seasonal differences increased. Therefore, age estimation using head length and body weight may be considered unreliable for individuals that are nine months or older. This may be of little concern during close demographic monitoring of *P. gunnii* due to their high trappability (Minta *et al.* 1990; Dufty 1994 *b*) and the likelihood that most individuals in the population will be encountered as juveniles, sub-adults or young adults.

The description of *P. gunnii* pouch young during this study was similar to descriptions given by Heinsohn (1966) and Lyne (1964; 1951). The head length for neonate *P. gunnii* (5.8 mm, this study; 5.3 mm, Heinsohn 1966) was similar to the head length of newborn *P. nasuta* (6.3 mm, Lyne 1964). Newborn *Isoodon* sp. may be similar in size (based on head length) to newborn *Perameles* sp. Mackerras and Smith (1960) determined a mean head length of 4.5 mm for *I. macrourus*, and Heinsohn (1966) determined that the head length of *I. obesulus* neonates from three litters were 5.8 mm, 6.6 mm and 6.0 mm.

Young remained in the pouch for about 46 days and after emergence were able to re-enter the pouch until about day 53. Similarly, Heinsohn (1966) believed the period of emergence occurred when young were aged between 48 and 53 days. A large range in body weights was observed for emergent young during both this study (mean = 81.4 g, range: 140-42.5 g) and Heinsohn's (1966) study (mean = 82.5 g, 143-61 g). The high variation in pouch young body weight may directly reflect the amount, and nutritional value, of milk produced by the mother. Stoddart and Braithwaite (1979) and Claridge *et al.* (1991) suggest that males frequently occupy optimal habitat and that few food resources and little shelter may be present in suboptimal areas (Dufty 1994 *c*). Female *P. gunnii* that inhabit suboptimal areas may need to forage longer, spend more time avoiding predators and conspecifics, and use more energy keeping warm than females in optimal habitat. Hence, the size of pouch young and timing of their emergence may be dependent on the mother's position in the dominance hierarchy in addition to seasonal and climatic factors. Heinsohn (1966) maintained a mother and pouch young alone in a captive enclosure (presumably with adequate food and shelter) and observed that the litter remained in the pouch until day 55 and periodically emerged and re-entered the pouch until day 58, considerably longer than was observed for free-ranging *P. gunnii* in Tasmania and Victoria.

Heinsohn (1966) believed that young were kept in a nest for several days after emergence. The youngest and oldest post-emergent dependent juveniles were 57 days and 86 days old and if a period of nest-life was present during this study, it probably occurred between day 46 (emergence) and day 57. Young appeared to be dependent on their mother until they are about 3 months old, after which female and male *P. gunnii* appear to become more independent and sexually active. Sexual maturity appears to occur at about 3.5 and 5 months for females and males respectively, although Heinsohn (1966) believed that females and males

reached sexual maturity at 3 and 4 - 5 months respectively.

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